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The role of reclaimed water for crop irrigation in southeast Spain

J. F. Maestre-Valero, M. J. González-Ortega, V. Martínez-Álvarez and B. Martin-Gorriz

ABSTRACT

Water shortages have led to measures such as the implementation of reclaimed water (RW) for irrigation in order to sustain agriculture. Waste water requires treatment to become a safe water resource for irrigation. This paper presents an analytical study on the use of RW for irrigation in the southeast of Spain, identifying its strengths and current limitations. It includes official data from 13 waste water treatment plants (WWTPs) belonging to two coastal irrigation districts in the Region of Murcia. The content of essential nutrients in some RWs might allow them to supply a large fraction of the fertilizers required by the crops, thus saving energy and reducing the cost of fertilization. However, the accumulation of chloride, sodium, and boron could damage soils and cause phytotoxicity to crops in the mid-term, reducing yields. Microbiological pollutants in the RW could also endanger human health and hence waste water treatment is required. In the selected WWTPs, all effluents met the minimum requirements established in Water Quality 2.3 by the Royal Decree 1620/2007 and also with the European Classes B and C proposed by COM[2018] 337. Blending RW and other water resources of better quality is recommended for the sustainable use of RW for irrigation.

Key words | energy savings, fertigation, legal framework, phytotoxic elements, water blending

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INTRODUCTION

The southeast of Spain is one of the areas with the highest levels of water scarcity in Europe. The important increase in agricultural water demand throughout recent decades together with severe climate change effects have led to a persistent water deficit in the region. In this context, the compulsory allocation of water creates significant conflicts between aggravated users during the periodic droughts. Thus, farmers have complemented their share of conventional water resources from other non-conventional sources, such as reclaimed waters (RW), in order to continue with their agricultural practices (Maestre-Valero *et al.* 2016).

The use of RW in agriculture has gained importance throughout recent decades. Convincing proof of this is the Region of Murcia, located in the southeast of Spain, where 100% of the RW produced in its 92 waste water treatment plants (WWTPs; 110 hm^3) is intended for irrigation and restores about 10% of the annual renewable resources (CHS 2015). In spite of this, RW may have been negatively viewed as a product commonly requiring disposal, as it may contain high concentrations of salt, leading to undesirable effects on soils and plants (Ayers & Westcot 1985) and viruses and other pathogens that can pose a potential health threat to the user (Parsons *et al.* 1995). Therefore, waste water treatment prior to its use for irrigation (Ongley 1996) and harmonizing of more specific chemical and microbiological legal controls (Royal Decree 1620/2007; COM[2018] 337) are required.

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However, it has been demonstrated that, under appropriate management, RW has great potential to become a valuable irrigation water source as (i) it is free-of-charge when the 'polluter pays' policy is implemented and (ii) it contains high levels of organic matter and nutrients which are essential for plant growth and might reduce fertilizer application rates with the associated energy and cost reduction (Maestre-Valero *et al.* 2016; Nicolás *et al.* 2016).

In the following sections, we analyze RW production in the Region of Murcia. In addition, considering two representative crops located in two coastal irrigation districts in southeastern Spain (lemon and lettuce crops), the role of the intrinsic essential nutrients (NO_3^-, PO_4^{3-}, K^+, Ca^{2+} and Mg^{2+}) of 13 WWTPs located in those districts and their contribution to the mineral nutrition were analyzed. The effect of the phytotoxic elements (Cl^-, Na^+, and B^{3+}) and the salinity in the RW on the crops and the soil and the microbiological constraints associated with the use of RW for irrigation were also studied. Finally, some management recommendations for the sustainable use of RW for irrigation have been made throughout the manuscript.

MATERIALS AND METHODS

Legal regulations and water quality scenarios

The reutilization of RW must meet with some specific physical, chemical and microbiological indicators before being safely used for irrigation. In Spain, such indicators are regulated in the Royal Decree 1620/2007. At EU level, there is a proposal for minimum quality requirements for water reuse in agricultural irrigation and aquifer recharge (COM [2018] 337).

Based on the farmers' mix of RW with other water resources, two water blending scenarios have been selected for the analyses: (i) 20% of RW mixed with 80% of transfer water through the Tajo-Segura aqueduct (TS) water (20% RW treatment), which may represent a common situation in some areas of the Region of Murcia; and (ii) 100% of RW (100% RW treatment), which may represent a situation of extreme water scarcity in the region.

Data processing

First of all, nutrient requirements (N, P, K_2O, CaO and MgO) for the selected crops (lemon and lettuce), have been documented (Benavente-García & López-Marín 2003; Soria-Alfonso 2008). Then, the percentages of essential nutrient satisfaction have been calculated based on the intrinsic nutrients at each water availability scenario: 100% RW or 20% RW, for the 13 WWTPs selected. The phytotoxic elements (Cl^-, Na^+ and B^{3+}) in the selected waters have been identified and have been compared with the maximum citrus thresholds for toxicity. In addition, the sodium adsorption ratio (SAR) has been calculated and its relation to the electrical conductivity (EC) has been analyzed to determine the soil sodification potential (Ayers & Westcot 1985). Salt tolerance of the most representative Mediterranean irrigated crops, i.e. lettuce, melon, pepper, tomato and orange, has also been analyzed based on its linear relation with yield reduction (Maas & Hoffman 1977). Finally, microbiology has been evaluated by comparison of helminth eggs, *Escherichia coli*, suspended solids and turbidity and the thresholds proposed in the Royal Decree 1620/2007 and COM [2018] 337. Data for the physical, chemical and microbiological examination of the RW produced at the selected WWTPs are official data provided by the '*Entidad de Saneamiento y Depuración de Aguas Residuales de la Región de Murcia*, ESAMUR' for the year 2016. For each parameter, the mean value for the 12 months in 2016 is presented in this study.

RESULTS AND DISCUSSION

Reclaimed water production in the Region of Murcia

In 2016, RW production in the WWTPs located in the Region of Murcia reached 110 hm^3. It is of note that 100% of the RW produced was reused for crop irrigation. The distribution of the different WWTPs and their RW productions in the Region of Murcia, grouped by agricultural districts, are shown in Figure 1.

Most of the WWTPs (88 out of 92) produced less than 4 hm^3/year and only three WWTPs produced more than that value; as expected, they were located in large population urban centers such as Cartagena (7.7 hm^3/year), Molina de Segura (5.1 hm^3/year) and Murcia East (35.7 hm^3/year) (Figure 1).

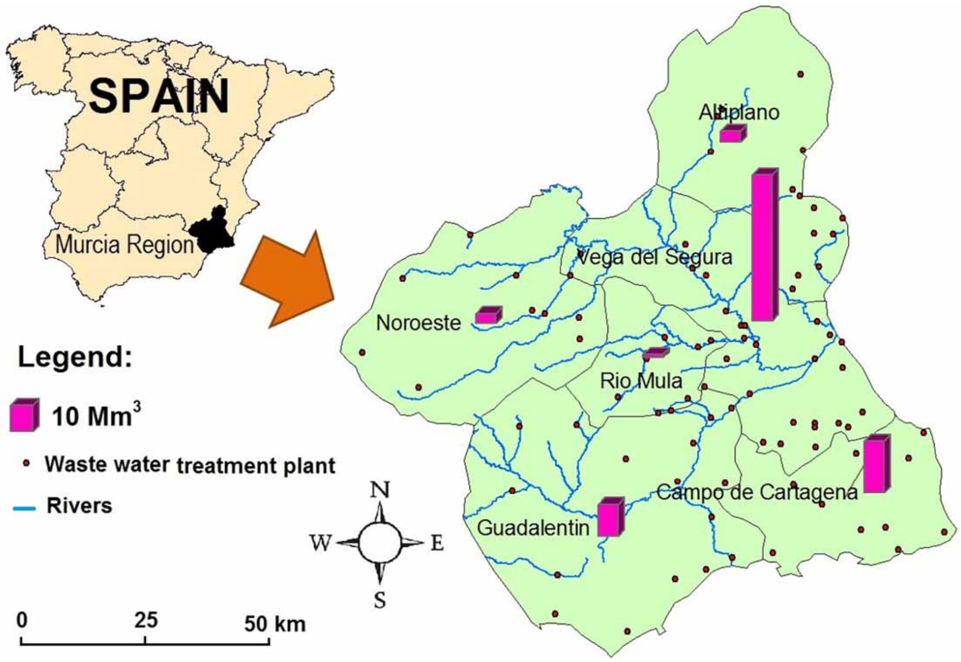

Figure 1 | Reclaimed water production for all the extant waste water treatment plants in the Region of Murcia (southeast of Spain) grouped by agricultural districts. Dashed dots represent the 13 selected waste water treatment plants belonging to two coastal irrigation districts in the Region of Murcia.

The role of the essential nutrients in the reclaimed water

Considering the intrinsic essential nutrients of the RW in the fertigation programs is an important task but it is even more relevant to know the final composition of the mix before programming fertigation. In this sense, taking into account the nutrient requirements for an adult lemon crop in the Region of Murcia (Soria-Alfonso 2008), irrigation with 100% RW could supply, depending on the WWTP, between 0.8% and 94.5% of NO_3^-, 3.4% and 24.8% of PO_4^{3-}, and all K^+, Ca^{2+} and Mg^{2+} requirements (Table 1). Under the 20% RW scenario, such values would range between 3.4% and 22.2% of NO_3^-, 1.8% and 6.0% of PO_4^{3-}, 40.8% and 64.9% of K^+ and all Ca^{2+} and Mg^{2+} requirements (Table 1).

Considering the nutrient requirements of a typical 90-day lettuce cycle in the Region of Murcia (Benavente-García & López-Marín 2003), irrigation with 100% RW could supply, depending on the WWTP, between 0.4% and 43.7% of NO_3^-, 1.0% and 7.4% of PO_4^{3-}, 22.1% and 45.1% of K^+ and all Ca^{2+} and Mg^{2+} requirements (Table 2). Under the 20% RW scenario, such values would range between 1.6% and 10.3% of NO_3^-, 0.5% and 1.8% of PO_4^{3-}, 7.7% and 12.2% of K^+ and all Ca^{2+} and Mg^{2+} requirements (Table 2).

These results manifest that considering the extant nutrients of the RW in the fertigation programs may have a significant impact on the economic cost of a great variety of farm systems (Nicolás *et al.* 2016). For instance, considering (i) the reclaimed water produced in the WWTP of Torre Pacheco, which is, from an agronomic point of view, absolutely valid for irrigation by itself, i.e. 100% RW scenario (Figure 2), (ii) the Tajo-Segura and RW prices according to Maestre-Valero *et al.* (2016) and (iii) the price of the fertilizers, the irrigation of lemon under the 100% RW scenario might allow an economic saving of 1,471 € (1,291 € in water and 180 € in fertilizer) compared with the 20% RW scenario (total cost of 2,423 € = 1,477 € in water and 946 € in fertilizers). In the case of lettuce, those economic savings might be of 382 € (311 € in water and 71 € in fertilizer) compared with the 20% RW scenario (total cost of 1,194 € = 357 € in water and 837 € in fertilizers).

Table 1 | Percentages of essential nutrient satisfaction for an adult lemon crop for the reclaimed water supplied by the 13 coastal waste water treatment plants selected in the Region of Murcia considering the 100% RW and the 20% RW scenarios

	NO_3^-		PO_4^{3-}		K^+		Ca^{2+}		Mg^{2+}	
Waste water treatment plants	**100% RW**	**20% RW**	**100% RW**	**20% RW**	**100% RW**	**20% RW**	**100% RW**	**20% RW**	**100% RW**	**20% RW**
1 Mazarrón	5.6 ± 3.2	4.4 ± 1.9	5.6 ± 1.8	2.2 ± 1.2	224.5 ± 54.4	62.3 ± 27.2	≫*100	≫100	≫100	≫100
2 La Unión	3.2 ± 0.8	3.9 ± 1.7	4.2 ± 2.8	2.0 ± 1.0	160.6 ± 12.6	49.2 ± 8.4	≫100	≫100	≫100	≫100
3 Roldan	8.1 ± 2.3	4.9 ± 2.1	4.0 ± 3.8	2.0 ± 1.2	155.9 ± 19.4	48.1 ± 9.4	≫100	≫100	≫100	≫100
4 Librilla	3.0 ± 1.8	3.9 ± 1.1	7.8 ± 1.0	2.6 ± 1.4	147.0 ± 23.5	46.6 ± 11.0	≫100	≫100	≫100	≫100
5 Torre Pacheco	7.3 ± 2.2	4.7 ± 0.9	3.4 ± 2.0	1.8 ± 2.0	163.3 ± 18.8	49.7 ± 12.0	≫100	≫100	≫100	≫100
6 Alhama Murcia	1.2 ± 0.2	3.5 ± 0.7	10.8 ± 8.0	3.2 ± 1.8	130.8 ± 17.8	43.4 ± 9.9	≫100	≫100	≫100	≫100
7 Puerto Lumbreras	0.8 ± 0.6	3.4 ± 1.1	24.8 ± 8.4	6.0 ± 2.4	150.7 ± 29.8	47.1 ± 9.4	≫100	≫100	≫100	≫100
8 Fuente Álamo	7.6 ± 5.3	4.8 ± 1.0	10.0 ± 4.8	3.2 ± 2.2	152.3 ± 19.4	47.6 ± 9.9	≫100	≫100	≫100	≫100
9 Totana	1.5 ± 0.6	3.5 ± 0.6	11.8 ± 4.8	3.4 ± 2.6	166.9 ± 48.7	50.8 ± 12.0	≫100	≫100	≫100	≫100
10 San P. Pinatar	11.8 ± 4.7	5.7 ± 1.9	7.8 ± 1.0	2.6 ± 2.2	175.8 ± 37.7	52.3 ± 16.2	≫100	≫100	≫100	≫100
11 San Javier	17.8 ± 8.0	6.9 ± 2.9	7.2 ± 3.2	2.6 ± 1.8	239.1 ± 35.1	64.9 ± 22.0	≫100	≫100	≫100	≫100
12 Los Alcazares	4.9 ± 2.8	4.3 ± 1.9	9.6 ± 2.8	3.0 ± 1.6	170.1 ± 17.8	51.3 ± 18.3	≫100	≫100	≫100	≫100
13 Mar Menor	94.5 ± 37.4	22.2 ± 9.8	8.6 ± 1.8	2.8 ± 2.2	117.2 ± 16.7	40.8 ± 14.7	≫100	≫100	≫100	≫100
Maximum	94.5 ± 37.4	22.2 ± 9.8	24.8 ± 8.4	6.0 ± 2.4	239.1 ± 35.1	64.9 ± 22.0	–	–	–	–
Minimum	0.8 ± 0.6	3.4 ± 1.1	3.4 ± 2.0	1.8 ± 2.0	117.2 ± 16.7	40.8 ± 14.7	–	–	–	–
Average	12.9 ± 24.9	5.8 ± 4.9	8.9 ± 5.5	2.9 ± 1.1	165.7 ± 33.4	50.3 ± 6.7	–	–	–	–

The following nutrient requirements have been considered: N = 190 kg/ha, P_2O_5 = 64 kg/ha and K_2O = 137 kg/ha, CaO = 17 kg/ha and MgO = 10 kg/ha (equivalent to NO_3^- = 108 mg/L, PO_4^{-3} = 50 mg/L, K^+ = 19 mg/L, Ca^{+2} = 2 mg/L and Mg^{+2} = 1.2 mg/L for an irrigation of 6,000 m^3/ha) (Soria-Alfonso 2008).

*≫ means much higher than 100%.

Table 2 | Percentages of essential nutrient satisfaction for an iceberg lettuce crop for the reclaimed water supplied by the 13 coastal waste water treatment plants selected in the Region of Murcia considering the 100% RW and the 20% RW scenarios

	NO_3^-		PO_4^{3-}		K^+		Ca^{2+}	
Waste water treatment plants	**100% RW**	**20% RW**	**100% RW**	**20% RW**	**100% RW**	**20% RW**	**100% RW**	**20% RW**
1 Mazarrón	2.6 ± 1.5	2.0 ± 0.9	1.7 ± 0.5	0.7 ± 0.4	42.3 ± 10.3	11.7 ± 5.1	≫*100	≫100
2 La Unión	1.5 ± 0.4	1.8 ± 0.8	1.3 ± 0.8	0.6 ± 0.3	30.3 ± 2.4	9.3 ± 1.6	≫100	≫100
3 Roldan	3.7 ± 1.1	2.3 ± 1.0	1.2 ± 1.1	0.6 ± 0.4	29.4 ± 3.6	9.1 ± 1.8	≫100	≫100
4 Librilla	1.4 ± 0.8	1.8 ± 0.5	2.3 ± 0.3	0.8 ± 0.4	27.7 ± 4.4	8.8 ± 2.1	≫100	≫100
5 Torre Pacheco	3.4 ± 1.0	2.2 ± 0.4	1.0 ± 0.6	0.5 ± 0.6	30.8 ± 3.6	9.4 ± 2.3	≫100	≫100
6 Alhama Murcia	0.6 ± 0.1	1.6 ± 0.3	3.2 ± 2.4	1.0 ± 0.5	24.7 ± 3.4	8.2 ± 1.9	≫100	≫100
7 Puerto Lumbreras	0.4 ± 0.3	1.6 ± 0.5	7.4 ± 2.5	1.8 ± 0.7	28.4 ± 5.6	8.9 ± 1.8	≫100	≫100
8 Fuente Álamo	3.5 ± 2.4	2.2 ± 0.5	3.0 ± 1.4	0.9 ± 0.7	28.7 ± 3.6	9.0 ± 1.9	≫100	≫100
9 Totana	0.7 ± 0.3	1.6 ± 0.3	3.5 ± 1.4	1.0 ± 0.8	31.5 ± 9.2	9.6 ± 2.3	≫100	≫100
10 San P. Pinatar	5.4 ± 2.2	2.6 ± 0.9	2.3 ± 0.3	0.8 ± 0.7	33.1 ± 7.1	9.9 ± 3.1	≫100	≫100
11 San Javier	8.2 ± 3.7	3.2 ± 1.3	2.2 ± 1.0	0.8 ± 0.5	45.1 ± 6.6	12.2 ± 4.1	≫100	≫100
12 Los Alcazares	2.3 ± 1.3	2.0 ± 0.9	2.9 ± 0.8	0.9 ± 0.5	32.1 ± 3.4	9.7 ± 3.5	≫100	≫100
13 Mar Menor	43.7 ± 17.3	10.3 ± 4.5	2.6 ± 0.5	0.8 ± 0.7	22.1 ± 3.2	7.7 ± 2.8	≫100	≫100
Maximum	43.7 ± 17.3	10.3 ± 4.5	7.4 ± 2.5	1.8 ± 0.7	45.1 ± 6.6	12.2 ± 4.1	–	–
Minimum	0.4 ± 0.3	1.6 ± 0.5	1.0 ± 0.6	0.5 ± 0.6	22.1 ± 3.2	7.7 ± 2.8	–	–
Average	6.0 ± 11.6	2.7 ± 2.3	2.7 ± 1.6	0.9 ± 0.3	31.2 ± 6.3	9.5 ± 1.3	–	–

The following nutrient requirements have been considered: N = 75 kg/ha, P_2O_5 = 50 kg/ha and K_2O = 175 kg/ha and CaO = 23 kg/ha (equivalent to NO_3^- = 233 mg/L, PO_4^{-3} = 167 mg/L, K^+ = 101 mg/L and Ca^{+2} = 12 mg/L for an irrigation of 2,450 m^3/ha) (Benavente-García & López-Marín 2003).
* ≫ means much higher than 100%.

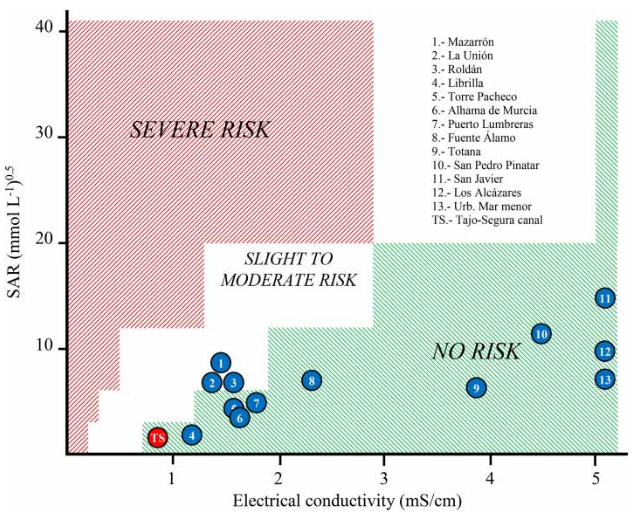

Figure 2 | Mid-long term soil sodicity potential risk, evaluated using the sodium adsorption ratio (SAR) and the electrical conductivity (EC) of irrigation water under the 100% RW scenario. Blue dots represent the mean values for RW supplied by the 13 coastal waste water treatment plants selected. The red dot represents the Tajo-Segura transfer. Please refer to the online version of this paper to see this figure in colour: http://dx.doi.org/10.2166/ws.2019.024.

Phytotoxic elements in the reclaimed water

The high concentration of Cl^-, Na^+, and B^{3+} in RW exposes soils and crops to their accumulation and causes specific injury to metabolic processes and tissues, thus reducing yields. The effects caused by the accumulation of these phytotoxic elements and their maximum thresholds are extensively reported in Martinez-Alvarez *et al.* (2017). For example, in the case of citrus, the maximum accepted concentrations of Na^+, Cl^-, and B^{3+} in irrigation water are about 115 mg/L, 350 mg/L and 0.5 mg/L, respectively (Grattan *et al.* 2015). As shown in Table 3, considering citrus trees under the 100% RW scenario, from the 13 selected WWTPs, only Librilla WWTP was below the Na^+ accepted maximum concentration, six WWTPs were below the Cl^- accepted maximum concentration and five WWTPs were below the B^{3+} accepted maximum concentration. In the case of the 20% RW scenario, seven

Table 3 | Phytotoxic elements (mg/L) of the reclaimed water supplied by the 13 coastal waste water treatment plants selected in the Region of Murcia considering the 100% RW and the 20% RW scenarios

	Cl^-		Na^+		B^{3+}	
Waste water treatment plants	**100% RW**	**20% RW**	**100% RW**	**20% RW**	**100% RW**	**20% RW**
1 Mazarrón	763.7	214.0	434.9	129.1	0.35	0.13
2 La Unión	248.5	111.0	176.6	77.5	0.70	0.20
3 Roldan	274.2	116.1	197.1	81.6	0.69	0.20
4 Librilla	114.4	84.2	90.8	60.3	0.06	0.08
5 Torre Pacheco	320.3	125.3	207.6	83.7	0.61	0.19
6 Alhama Murcia	223.2	105.9	162.2	74.6	0.19	0.10
7 Puerto Lumbreras	223.5	106.0	177.7	77.7	0.16	0.10
8 Fuente Álamo	394.7	140.2	287.7	99.7	0.26	0.12
9 Totana	714.1	204.1	434.6	129.1	0.71	0.21
10 San P. Pinatar	1,115.4	284.4	694.5	181.1	1.24	0.31
11 San Javier	1,817.5	424.8	1,067.2	255.6	1.24	0.31
12 Los Alcazares	1,198.2	300.9	719.8	186.1	1.33	0.33
13 Mar Menor	1,031.4	267.6	621.6	166.5	1.53	0.37
TS Tajo-Segura*	76.6	76.6	52.7	52.7	0.08	0.08
Maximum	1,817.5	424.8	1,067.2	255.6	1.5	0.4
Minimum	114.4	84.2	90.8	60.3	0.1	0.1
Average	649.2	191.1	405.6	123.3	0.7	0.2

*Mean value during 2011–2013.

WWTPs were below the Na^+ accepted maximum concentration, 12 WWTPs were below the Cl^- accepted maximum concentration and all WWTPs were below the accepted maximum concentration of B^{3+} (Table 3). Therefore, it is evident that, to mitigate the risk of crop damage associated with phytotoxic elements, smart on-farm strategies such as blending RW with other water resources of better quality such as surface or desalinated waters are required to ensure agricultural sustainability of lands irrigated with RW.

Apart from the direct phytotoxicity, the high Na^+ concentration in RW may produce the impairment of the soil's physical conditions due to sodicity as an indirect effect, affecting crop yield. Sodicity deteriorates the soil's physical properties in the form of clay dispersion leading to: (i) the structural collapse of soil aggregates; (ii) decreased soil hydraulic conductivity; (iii) erosion problems; (iv) soil compaction; and (v) decreased soil aeration (Muyen *et al.* 2011). Its evaluation may be conducted using the sodium adsorption ratio (SAR) and its relation to the electrical conductivity (EC) (Ayers & Westcot 1985) (Figure 2). Most of the RW produced at the WWTPs showed remarkably high values of Na^+ and SARs (Table 3; Figure 2). However, due to the high EC, only three WWTPs (Mazarrón, La Unión and Roldán) showed some slight to moderate sodicity risk (Figure 2). In these latter cases, this could cause a drop in the soil infiltration rate in the mid-term and also hinder infiltration drainage and diffused atmospheric oxygen flux through soils (Ayers & Westcot 1985).

Under the 20% RW scenario, all the WWTPs showed no risk of mid–long-term soil sodicity damage due to their low SAR and EC (data not shown).

Additionally, salt tolerance may be analyzed as the relation of the crop yield and the soil salinity by a linear response function characterized by a salinity threshold value below which the yield is unaffected and above which the yield decreases linearly with salinity (Maas & Hoffman 1977). Figure 3 presents the model and provides threshold values for some representative Mediterranean irrigated crops and the EC of the selected WWTPs. Considering the 100% RW scenario, within the 13 selected WWTPs, five exceeded an EC of 3.5 dS/m which might make irrigation with the RW non-viable (Figure 3(a)). However, under the 20% RW scenario, practically all the WWTPs had an EC lower than 2 dS/m and hence, much more limited crop yield reductions (Figure 3(b)).

Microbiological constraints

Table 4 shows helminth eggs, *Escherichia coli*, suspended solids and turbidity in the RW produced at the 13 WWTPs (100% RW scenario).

It is of note that all effluents from the WWTPs met the minimum requirements established in Water Quality 2.3 by the Royal Decree 1620/2007 and also with the European Classes B and C proposed by COM [2018] 337. Likewise, all effluents met the minimum requirements established in Water Quality 2.1 by the Royal Decree 1620/2007. However, if (COM [2018] 337) thresholds are set as a reference, only 69% (nine out of 13 WWTPs) of analyzed effluents would meet the water quality Class A for *E. coli* Upon analyzing the 20% RW scenario, even the most limited WWTP for *E. coli*., Fuente Álamo, fulfills the Class A quality requirements

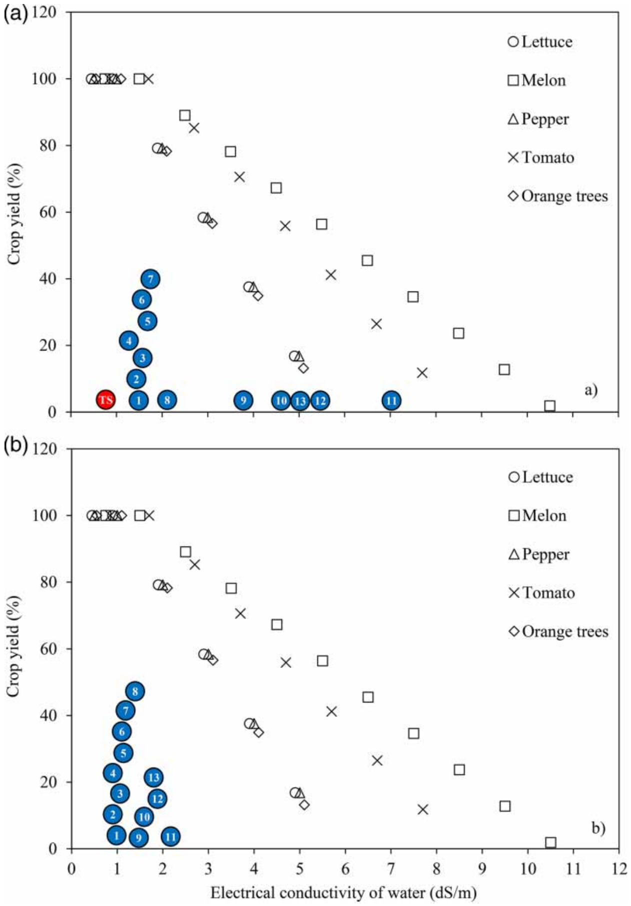

Figure 3 | Electrical conductivity threshold values for some representative Mediterranean irrigated crops and electrical conductivity of the selected WWTPs (a) for the 100% RW scenario and (b) for the 20% RW scenario. Blue dots represent the mean values for RW supplied by the 13 coastal waste water treatment plants selected. The red dot represents the Tajo-Segura transfer. Numbers are defined in Figure 2. Please refer to the online version of this paper to see this figure in colour: http://dx.doi.org/10.2166/ws.2019.024.

for water reuse in agricultural irrigation (COM [2018] 337) (data not shown).

CONCLUSIONS

The high concentration of some essential nutrients such as NO_3^-, PO_4^{3-}, K^+, Ca^{2+} and Mg^{2+} in reclaimed water (RW) has evidenced that fertigation with RW programs must be adapted, saving energy and operational costs. Special attention must be paid to phytotoxic elements such as Cl^-, Na^+, and B^{3+}, as their accumulation may damage soils and cause phytotoxicity to crops, hence reducing yields. Therefore, periodic controls of nutrients in the soil and leaf tissues are strongly recommended. In the selected WWTPs, all effluents have met the minimum requirements established in Water Quality 2.3 by the Royal Decree 1620/2007 and also with the European Classes B and C proposed by COM [2018] 337. If maximum values for these parameters were analyzed, the results would be more restrictive in some periods of the year.

This study hence evidences that RW can contribute to partially removing the hydrological constraints for crop production in water-stressed regions, but specific water management strategies, such as mixing with other conventional sources and seasonal soil monitoring, should be considered to avoid food safety problems and salinization and deterioration of agro-systems.

Table 4 | Mean values for helminth eggs, *Escherichia coli*, suspended solids and turbidity in the RW produced in the 13 coastal WWTPs under the 100% RW scenario

Waste water treatment plants	Helminth eggs (eggs/10 L)	*Escherichia coli* (UFC/100 ml)	Suspended solids (mg/L)	Turbidity (NTU)
1 Mazarrón	0.0 ± 0.0	9.8 ± 39.2	7.3 ± 3.5	4.1 ± 1.6
2 La Unión	0.0 ± 0.0	9.3 ± 22.8	5.2 ± 5.5	4.8 ± 3.2
3 Roldan	0.0 ± 0.0	14.2 ± 34.6	4.8 ± 2.2	3.6 ± 1.4
4 Librilla	0.0 ± 0.0	16.3 ± 39.9	3.6 ± 2.8	2.4 ± 1.8
5 Torre Pacheco	0.0 ± 0.0	7.2 ± 11.9	3.4 ± 1.5	2.5 ± 1.3
6 Alhama de Murcia	0.1 ± 0.3	17.8 ± 36.1	8.1 ± 6.1	4.8 ± 2.8
7 Puerto Lumbreras	0.1 ± 0.3	3.8 ± 10.3	3.1 ± 1.6	1.9 ± 0.9
8 Fuente Álamo	0.1 ± 0.4	42.2 ± 56.9	5.3 ± 1.5	2.7 ± 0.6
9 Totana	0.0 ± 0.2	5.1 ± 18.1	3.7 ± 1.5	2.2 ± 0.9
10 San Pedro del Pinatar	0.0 ± 0.0	0.0 ± 0.0	2.1 ± 0.2	1.2 ± 0.5
11 San Javier	0.0 ± 0.0	3.1 ± 15.5	3.8 ± 1.8	2.5 ± 1.9
12 Los Alcázares	0.0 ± 0.0	3.9 ± 11.5	4.4 ± 5.1	2.3 ± 2.1
13 Urbanización Mar Menor	0.0 ± 0.0	7.6 ± 19.2	4.0 ± 2.9	1.9 ± 1.1
Maximum	0.1 ± 0.4	42.2 ± 56.9	8.1 ± 6.1	4.8 ± 3.2
Minimum	0.0 ± 0.0	0.0 ± 0.0	2.1 ± 0.2	1.2 ± 0.5

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